Report for 2002MS6B: A Single Technology for Remediating PNAs, Nitro/Nitrate Residues, PCBs, CAHs, Herbicides and Pesticides from Soils and Sludges with Na/NH3(l)

There are no reported publications resulting from this project.

Report Follows:

PROBLEMS AND RESEARCH OBJECTIVES:

The key goal of this project is to develop Na/NH_3 solvated electron reductions as a technology to rapidly remediate soils and sludges which have been contaminated with one or more of the following classes of polluting compounds:

(a) polychlorinated biphenyls (PCBs)
(b) chlorinated aliphatic hydrocarbons (CAHs)
(c) nitro/nitrate wastes (military wastes)
(d) pesticides and herbicides (chlorinated/brominated and phorphorous compounds)
(e) polynuclear aromatic hydrocarbons (PNAs)

This single technology has the potential to remove all these classes of toxic compounds from contaminated soils simultaneously. Over the past three years we have thoroughly investigated and demonstrated the rapid destruction of neat PCBs, CAHs and several pesticides as well as soils (with up to 20%wt. water) contaminated with these three classes of pollutants [1-12]. Furthermore, several samples from superfund sites, which were contaminated with PCBs, CAHs, dioxins and nitro compounds, were successfully remediated to very low (or nondetectable) pollutant levels [8,10].

METHODOLOGY:

Based on this highly successful research we began to test the reduction of a large series of polynuclear aromatic hydrocarbons (PNAs) and showed that neat samples were essentially totally reduced, leaving almost no traces of the residual PNAs [8,12]. Thus, the focus of the work turned towards identifying the reduction products produced in these neat reactions and examining the remediation of model PNA-contaminated soils [12,13]. The key findings are summarized as follows without going into the details.

1. With the exception of naphthalene and anthracene, very complex mixtures of reduction products result with more complex PNAs such as phenanthrene, chrysene, benzo-substituted anthracenes, pyrene etc [12,13].
2. Determining the reduction product distribution in treated soils was very difficult or impossible.
3. The product distribution changes with reduction time, soil makeup, water content in the soil and subsequent exposure of the remediated soil to air [13].
4. Environmental samples contaminated with PNAs typically contain complex mixtures of these pollutants. Therefore, after treatment with Na/NH_3, the product distributions of reduction products are extremely complex. Accurate analysis of these distributions in the remediated soils is too complex to be tractable.
5. The amount of sodium consumption required to remediate the contaminated soils was far greater than that required to remediate neat samples to the same low PNA residue concentrations (1ppm for example) [12,13].
6. The high sodium consumptions required during soil treatments (relative to treating pure PNAs) are due to the relatively slow PNA reduction kinetics in Na/NH_3 media. Therefore, water and other impurities in soil are able to complete with the PNA reductions and consume more sodium. Thus, higher amounts of sodium are required.

RESULTS/DISCUSSION:

In our most recent work, we have demonstrated that soils containing PNA mixtures (for example napthalene, anthracene, pyrene, chrysene and benzo["]anthracene) may be successfully remediated. Thus, all of the PNA species in the soils can be reduced to low levels using excess sodium in NH_3. Since, this generates very complex, unanalyzable product mixtures in the soil, there is a requirement that one demonstrate that these product mixtures are safe to leave in the soils. Each particular PNA mixture will give a unique product distribution and this distribution will be different for every different soil composition encountered (even if the PNA contaminate mixture's composition is held constant). Thus, we have started to work with Professor Shiao Wang at the University of Southern Mississippi to develop an evaluation method to see if the PNA-contaminated soils are safe to return to the environment after Na/NH_3 remediation treatments [14]. This project is now combining the recent methods of *biotechnology* with *chemical reduction methods*.

A series of individual PNA-contaminated soils were reduced with Na/NH_3. We have also reduced soils contaminated with PNA mixtures. These samples, along with samples of the reduction products from pure PNA compound reductions, have been sent to Professor Wang at USM. Professor Wang will expose water to these samples individually. This water will then be used as a medium to grow both minnows and/or freshwater mussels. The same species of freshwater mussels and minnows will also be raised, simultaneously, in identical tanks, using pristine water (which never encountered the PNA reduction product or remediated soils with the PNA reduction products). Then, DNA-chip technology will be employed to do scans of a large series of genes to see which genes have been activated (e.g. gene expression turned on). By sampling hundreds or thousands of genes, a general DNA expression array will be obtained for these organisms when living in the pristine water versus that when living in the water exposed to the PNA reduction products. These organisms will serve as environmental sentinels by comparing the up-regulation versus down-regulation of their gene expression as shown by the DNA arrays on a chip. Early indications of environmental stresses placed on the organisms will be revealed by these patterns of gene expression. This will occur long before these species exhibit signs of sickness or die. This should be a far more sensitive technique than looking at organism death rates.

Experiments with minnows are going on at USM now. The DNA-chip technology is in a start-up phase in Professor Wang's lab. His students have about 10 samples from our laboratory waiting to be studied. A chip-reader at the Army Corp of Engineers (WES) in Vicksburg will be employed. We can do nothing at MSU to speed up this progress. We are significantly in front of USM in accomplishing our portion of this work.

While waiting for the USM experiments to begin producing results, we are conducting experiments on PNA model compounds and model mixtures, which are mixed with PCBs, or a model nitroaromatic compound. Then these mixtures are being subjected to dry Na/NH_3 or Na/NH_3 with 2%wt. water added. For example, when the PNA, phenanthrene, and dinitrobenzene were mixed and subjected to Na/NH_3 treatment, these two pollutants were reduced from concentrations of 2000 ppm each to levels below 5 ppm when 2%wt. water was present.